

# WALKING ON AN OSCILLATING TREADMILL: TWO PATHS TO FUNCTIONAL ADAPTATION

<sup>1</sup>Rachel A. Brady, <sup>1</sup>Brian T. Peters, and <sup>2</sup>Jacob J. Bloomberg

<sup>1</sup>Wyle Integrated Science and Engineering Group, Houston, TX, USA

<sup>2</sup>Neuroscience Laboratories, NASA Johnson Space Center, Houston, TX, USA

email: [rachel.bradyl@nasa.gov](mailto:rachel.bradyl@nasa.gov)

## INTRODUCTION

We mounted a treadmill on top of a six degree-of-freedom motion base platform to investigate and characterize locomotor responses produced by healthy adults when introduced to a novel walking condition. Subjects were classified into two groups according to how their stride times were affected by the perturbation. Our data suggest that a person's choice of adaptation strategy is influenced by the relationship between his unique, natural stride frequency and the external frequency imposed by the motion base.

## METHODS

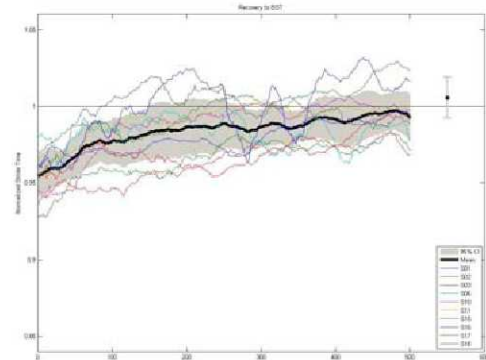
Twenty healthy adults (12 men), average ( $\pm 1$  S.D.) age 37 ( $\pm 9$ ) years, walked at 4 km/h (2.5 mph) on a laterally oscillating treadmill that moved in a continuous, sinusoidal pattern at a frequency of either 0.2 Hz or 0.3 Hz. Each subject's baseline stride time (BST) was determined during a period of normal treadmill walking prior to the onset of base motion. Stride time data for the perturbation portion of the exposure was normalized to this BST.

Most subjects settled into a comfortable, adapted walking strategy within the first 10 minutes of the 20 minute trial. To focus on the acute phase of adaptation, we restricted our stride time analysis to these first 10 minutes.

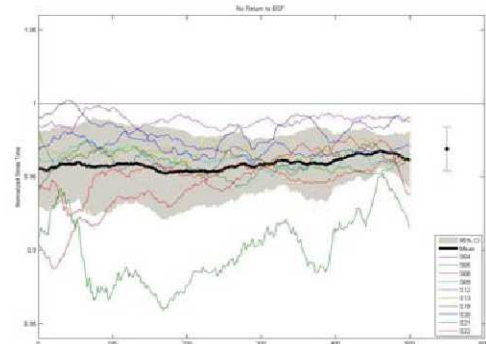
## RESULTS AND DISCUSSION

Immediately following motion base movement onset, all participants demonstrated a rapid decrease in stride time, presumably as a strategy for maintaining postural stability. After this initial decrease, stride times for some individuals (Return

Group, Figure 1) trended back toward their baseline values while stride times for others (No Return, Figure 2) never made a return.



**Figure 1:** Return Group. Stride times for 10 subjects trended toward their BSTs during the first 10 minutes of exposure. By the last 5 minutes of the trial, indicated here by the point at the right, these subjects reacquired their BSTs.

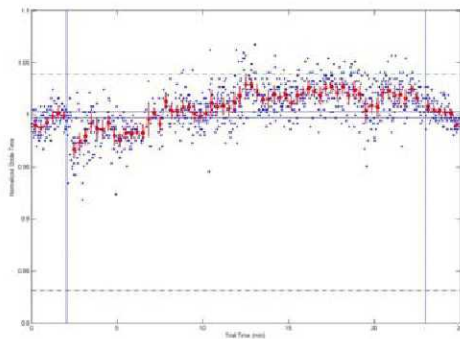


**Figure 2:** No Return. Stride times for 10 subjects did not return to their BSTs.

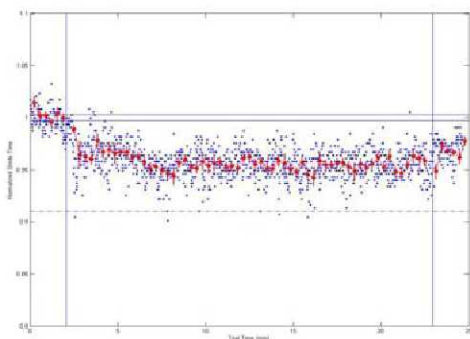
A possible conclusion might be that the No Return group did not “adapt” to the base motion, but we believe otherwise. Functionally, participants in both groups appeared to be equally and fully adapted, able to walk comfortably and effortlessly on the moving platform, although a review of their stride

time data suggests they accomplished this in different ways. To investigate why this might be happening, we looked at the relationship between a person's natural stride frequency and the external frequency imposed by the motion base.

Stride times that would result in an integer ratio between a subject's heel strike events and the lateral movement of the support surface were calculated and labeled as entrainment stride times (EST). Due to variation in the individual BSTs between subjects, the relationships between their BSTs and ESTs were also unique. ESTs were those strides times that would produce three (3:1) or four (4:1) strides per support surface cycle. A subject's nearest EST could have been higher (Figure 3) or lower (Figure 4) than his BST, or it could have been at his BST, which appears in the figures at 1 on the y-axis.



**Figure 3:** Example of normalized stride time data for a subject whose nearest EST (dotted green line) was higher than his BST, represented on the y-axis at 1.



**Figure 4:** Example of normalized stride time data for a subject whose nearest EST (dotted red line) was lower than his BST, represented on the y-axis at 1.

We believe that during adaptation, participants were influenced by two attractors, their natural stride frequency (BST) and the stride frequency required to achieve entrainment with the motion base (EST). Nine of ten subjects in the Return Group had ESTs at or above their BSTs, positioning both attractors in a positive direction that would draw a return toward the BST. Seven of ten subjects in the No Return Group had ESTs below their BSTs, positioning one attractor (BST) in a positive direction and the other (EST) in the negative. We believe these subjects were drawn away from the BST attractor by the EST.

## CONCLUSIONS

Our data suggest that a person's stride time response while walking on a laterally oscillating treadmill is influenced by the relationship between his unique, natural stride frequency and the imposed external frequency of the motion base. This relationship may be useful for checking the efficacy of gait training and rehabilitation programs. Pre-selecting and manipulating a person's EST could be one way to draw him out of his preferred "entrainment well" during therapy or training.

## ACKNOWLEDGEMENTS

This work was supported by the National Space Biomedical Research Institute through NASA NCC 9-5.